nerves; nor the researches of Weir Mitchell on the functions of nerve-centres, and the action of snake-poisons; nor, in later years, the researches of Wood on the physiology of fever; and on various subjects by Bowditch, Arnold, Flint, Minot, Sewall, Ott, Chittenden, Prudden, Keyt, and others. But speaking with all the diffidence which one, who, at least by birth, is a foreigner, must feel in expressing such an opinion, I say, that considering the accumulated wealth of this country, the energy which throbs through it, and the number of its medical schools, it has not done its fair share in advancing physiological knowledge, *but for one thing*, which makes the world its debtor. I mean the discovery of anaesthetics. When Morton, in 1846, demonstrated in the Massachusetts general hospital that the inhalation of ether could produce complete insensibility to pain, he laid the foundation-stone of our laboratory, and of many others. No doubt the men whose instincts led them to physiological research, and who realized that by the infliction of temporary pain on a few of the lower animals they were discovering truths which would lead to alleviation of suffering, and prolongation of life, not only in countless generations of such animals themselves, but in men and women to the end of time, would have tried to do their work in any case. But the men who can steel their hearts to inflict present pain for a future greater gain are few in number. The discovery of anaesthetics has not only led to ten physiological experimenters for each one who would have worked without them, but by making it possible to introduce into the regular course of physiological teaching, demonstrations and experiments on living animals, without shocking the moral sense of students or of the community at large, has contributed incalculably to the progress of physiology.

On the occasion of the opening of the old laboratory I used these words:[1] —

"Physiology is concerned with the phenomena going on in living things, and vital phenomena cannot be observed in dead bodies; and from what I have said you will have gathered that I intend to employ vivisections in teaching. I want, however, to say, once for all, that here, for teaching purposes, no painful experiment will be performed. Fortunately the vast majority of physiological experiments can nowadays be performed without the infliction of pain, either by the administration of some of the many anaesthetics known, or by previous removal of parts of the central nervous system; and such experiments only will be used here for teaching. With regard to physiological research, the case is different. Happily here, too, the number of necessarily painful experiments is very small indeed; but in any case where the furtherance of physiological knowledge is at stake — where the progress of that science is concerned, on which all medicine is based, so far as it is not a mere empiricism — I cannot doubt that we have a right to inflict suffering upon the lower animals, always provided that it be reduced to the minimum possible, and that none but competent persons be allowed to undertake such experiments."

Those words were a declaration of principle and a pledge given to this community, in which I was about to commence my work. That the work has been carried on for seven years among you, without a murmur of objection reaching my ears, is sufficient proof that Baltimore assents to the principle; and, gratifying as the building of our new laboratory is to me from many points of view, there is none so grateful as its witness, that, in the opinion of our trustees and of my fellow-citizens, I have carried out my pledge. There has been no hole-and-corner secrecy about the matter: the students in the laboratory have been no clique living isolated in a college-building, but either your own sons, or boarders scattered among dozens of families in this city; and no room in the laboratory has ever been closed to any student: what we have done has been open to all who cared to know. On this occasion, when we formally make a fresh start, I desire to re-assert the principle, and repeat the pledge.

[1] *Pop. sc. monthly*, November, 1876.

(*To be concluded.*)

BERTHELOT'S EXPLOSIVE MATERIALS.

Explosive materials, a series of lectures delivered by M. P. E. BERTHELOT; *translated by* MARCUS BENJAMIN. *A short historical sketch of gunpowder; translated from the German of* KARL BRAUN *by* Lieut. JOHN P. WISSER, U.S.A. *A bibliography of works on explosives; reprinted from Van Nostrand's magazine*, No. 70. N.Y., *Van Nostrand*, 1883. (Van Nostrand's science series.) 180 p. 24°.

THE lectures of Berthelot, which form the more important part of this collection, are devoted to a popular exposition and amplification of the theories which he has from time to time advanced, concerning the constitution and mode of action of explosive substances. The principal topics treated are, the force of explosives; the origin, duration, and speed of propagation of the explosive reactions; inflammation and detonation as modes of inducing explosions; and explosions by influence.

The force of an explosive may be understood in two ways: it may be considered either as the pressure developed or as the work accomplished. The pressure depends principally upon the nature of the gases formed, their volume, and their temperature. The work, on the other hand, is principally dependent upon the amount of heat given off in consequence of the chemical decomposition. In practice, as, for instance, in guns, the transformation of this heat into useful work is never complete, since heat is absorbed by the gun, gases, and projectile, and a portion of the work produced is lost in moving the gases and air projected. Taking all these facts into consideration, it has yet been difficult to explain the great differences which result from the different methods employed for inducing explosions. Berthelot holds that this diversity depends upon the rapidity with which the explosive reaction propagates itself, and the more or less intense pressures which result from it, and he illustrates it as follows: —

Let the case be the simplest one, such as an explosion caused by the fall of a weight from a certain height. At first one would suppose the effects observed to be due to the heat developed by the pressure of the suddenly arrested weight. But calculation shows that the arresting of a weight of several kilograms, falling .25 to .50 of a metre, would not be capable of raising the temperature of the explosive mass more than a fraction of a degree, if the resulting heat were dispersed uniformly throughout the entire mass; while for a body such as nitro-glycerine, for instance, it is necessary to heat it to 190° to induce explosion.

It is by another process that the mechanical energy of the weight, which is transformed into heat, becomes the originator of the observed effects. It is sufficient to assume, that, as the pressures which arise from the shock exerted on the surface of the nitro-glycerine are too rapid to become uniformly dispersed throughout the entire mass, the transformation takes place locally among the layers first reached by the shock. If it is sufficiently violent, they may thus be rapidly heated to the necessary temperature; and they will be immediately decomposed, and produce a large quantity of gas. This production of gas is in its turn so violent that the shocking body has not time to displace itself; and the sudden expansion of the gases of explosion produces a new shock, probably more violent than the first, on the layer situated below. The mechanical energy of this shock is changed into heat in the layers which it reaches, and produces an explosion; and this alternation between a shock developing mechanical energy which changes into heat, and a production of heat which elevates the temperature of the layers up to the degree necessary for a new explosion capable of reproducing the shock, propagates the reaction, molecule by molecule, through the entire mass. The propagation of the deflagration takes place in this way in consequence of phenomena comparable to those which produce a sonorous wave; that is to say, by producing a real explosion which advances with a rapidity incomparably greater than that of a simple burning provoked by the contact of a body in ignition, and operating under conditions where the gases expand freely in proportion to their production.

The reaction started by the first shock in a given explosive material is propagated with a rapidity which depends upon the intensity of the first shock; and this intensity may vary considerably, according to the method by which it is produced. Marcel Duprez has shown that the effect of a blow from a hammer may vary in duration from the hundredth to the ten-thousandth of a second, according as one strikes with a hammer having a flexible handle or with a block of steel. From this it follows that the explosion of a solid or liquid mass may develop itself according to an infinite number of different laws, each one of which is determined, all other things being equal, by the original impulse. The more violent the initial shock, the greater will the resulting violence of the decomposition be, and the greater will be the pressures which are exerted during the entire course of this decomposition. One and the same explosive substance may hence produce very different effects, according to the method of ignition.

Among these methods of ignition, by far the most curious and inexplicable is the determining of the explosion of one mass by the explosion of another mass near by, but not in contact with it, which is termed by Berthelot 'explosion by influence.' Abel has offered his theory of *synchronous vibrations* to explain this phenomenon, and the theory seemed to be confirmed by the interesting experiments of Champion and Pellet; but Berthelot regards them as inconclusive, or else directly opposed to Abel's theory, and he offers a theory of his own, which is but an expansion of that of shocks explained above.

Working, as Berthelot is, under the direct auspices of the French government, he has had the best of facilities for the study of explosive substances and the phenomena of explosions; and no one has probably engaged in a more critical or extended physical and chemical examination of these bodies, and hence he speaks with authority. Yet some of his theories have failed to find general acceptance, especially that concerning the influence of dissociation upon the force of explosives; and it is noticeable that this theory finds no place in these lectures.

Karl Braun's sketch is bright and entertaining but iconoclastic, and, while wresting the honor of the discovery of gunpowder from Berthold Schwartz, intimates that the knowledge of its manufacture was brought from the orient to Augsburg in 1353 by a Greek Jew named Typsiles.

Of the 'Bibliography of explosives' the best that can be said is, that it is an unsystematized collection of titles, that it is filled with errors of the grossest kind, and that it is unworthy of both compiler and publisher. In fact, it must be said the book throughout is marred by printers' errors.